P B M R

Pebble Bed Modular Reactor

In
the 1950's,
Dr. Rudolf Schulten
(later Prof. Dr. Schulten,
"father" of the pebble bed
reactor) had an idea. The idea was to
compact carbon-coated uranium granules
into hard billiard-ball-like spheres to be used as
fuel for a new high temperature, helium cooled type of
reactor. The idea took root and in due course the AVR, a
15MW (megawatt) demonstration pebble bed reactor, was built
in Germany. It operated successfully for 21 years. Then,
in the intense wave of post-Chernobyl anti-nuclear
sentiment that swept Europe, particularly
Germany, the idea almost submerged.
It is resurfacing in South
Africa ...

T/9

THE KEY TO CLEAN, SAFE AND AFFORDABLE ENERGY

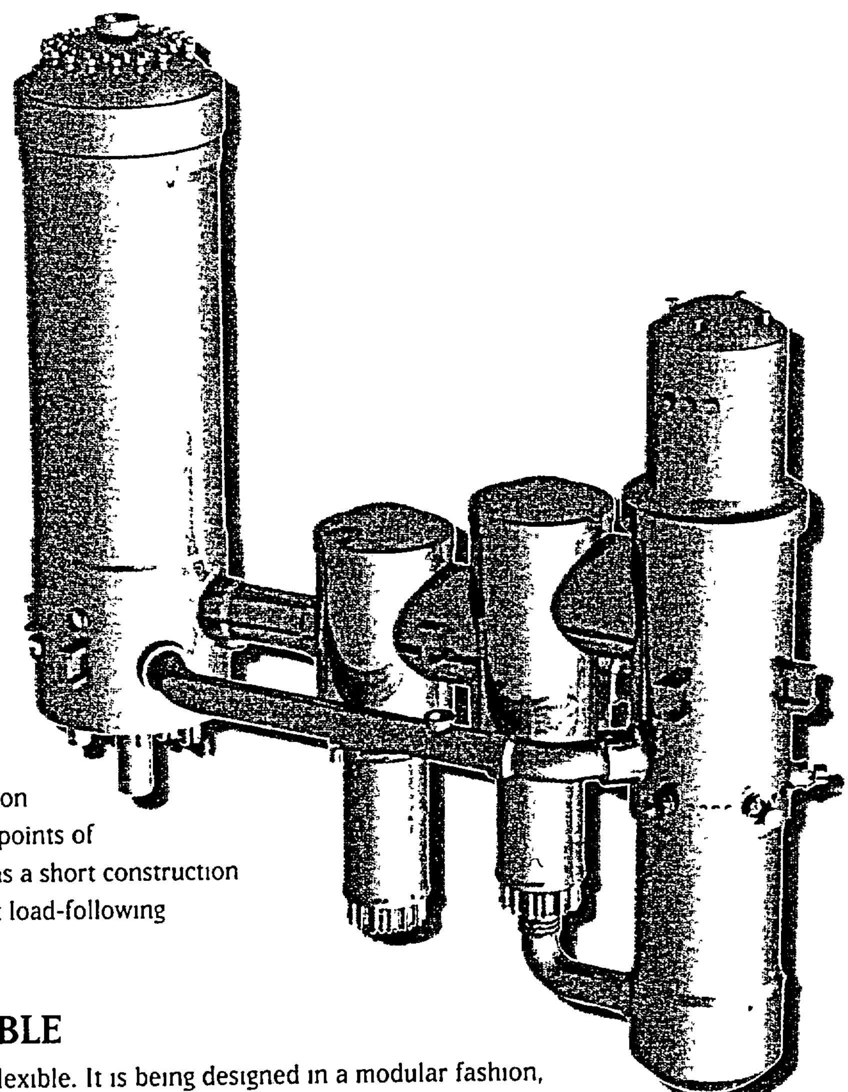
It is small, safe, clean, cost efficient, inexpensive and adaptable. Those, in a nutshell, are the features of the Pebble Bed Modular Reactor (PBMR)

The PBMR is currently being investigated by Eskom, South Africa's power utility giant, to establish whether it could be included as an option in South Africa's future energy generation mix. Design and costing studies indicate that the PBMR has a number of advantages over other potential power sources. Locally, it has the potential to provide South Africa with competitive power generation in coastal areas Internationally, it will be highly competitive with virtually all other forms of energy generation

Most of South Africa's coal-fired electricity is generated by large-scale plants built near the pit-heads of two extensive coal-producing areas, both of them far inland on the eastern side of the country.

This requires long power lines from the coal-rich areas to load centres away from the pit-heads, which in turn implies high capital costs and transmission losses Transporting coal to distant power stations is prohibitively expensive. The opportunities for producing hydro-electric power or power from natural gas in South Africa are severely limited.

Although the demand in South Africa is currently lower than the capacity, it is anticipated that new capacity will have to be commissioned by about 2007. Even moderate growth of 2,5 percent will result in peak electricity demand exceeding capacity between 2005 and 2010 In addition, Eskom's older power stations reach the end of their design life after 2025



South Africa will, therefore, need to access and use all natural resources to produce the additional 20 000MW of electricity that will be needed by 2025 (over and above the about 40 000MW currently available, in cold storage, moth-balled or under construction).

Large thermal, nuclear or hydro-electric power stations require lead times of up to eight years and could result in the installation of surplus capacity if economic growth is not as expected

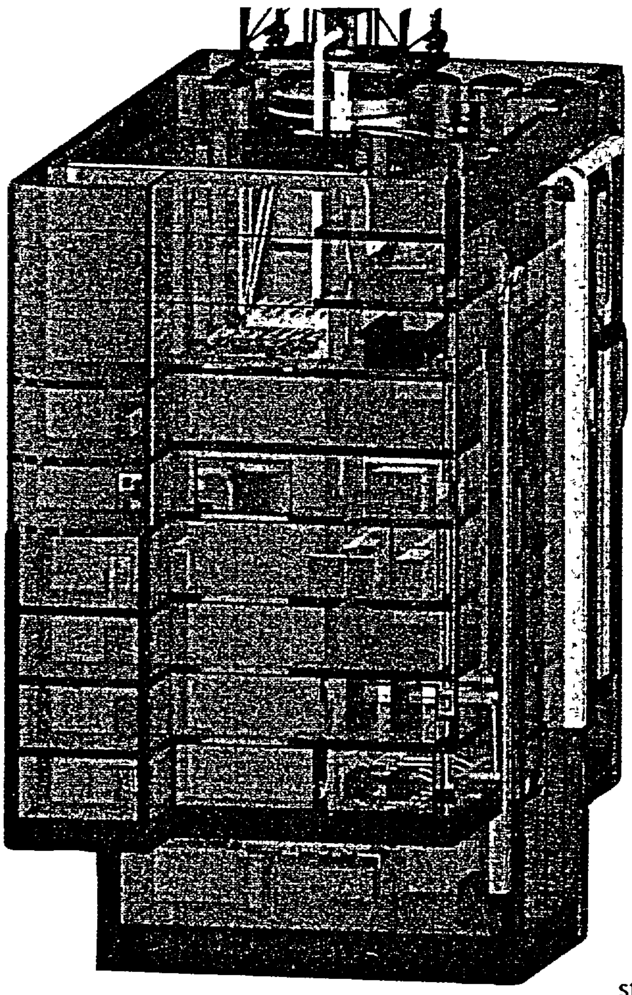
Eskom also experiences short, sharp demand peaks in winter that are difficult to accommodate with the slow ramping characteristics of the existing large power stations.

These factors prompted Eskom to contemplate small electricity generation plants that can be placed near to the points of demand The PBMR concept, which has a short construction lead-time, low operating cost and fast load-following characteristics, is such an option

THE PBMR IS ADAPTABLE

The PBMR reactor is adaptable and flexible. It is being designed in a modular fashion, which allows for additional modules to be added in accordance with demand It is much less location-dependent than hydro-electric or fossil-fuelled power stations

Dry cooling, although more expensive, is an option that would provide even more freedom of location They can be used as base-load stations or load-following stations and can be configured to the size required by the communities they serve An added attraction is that they are extremely well suited for desalination purposes



THE PBMR IS SMALL

The PBMR is based on the philosophy that the new generation of nuclear reactors should be small. A single PBMR module would be sized to produce about 110MW, which is about 10 percent of the output of a conventional nuclear or fossil fuel-driven power station The modular approach makes it possible to build smaller nuclear power plants to serve local needs and expand them as demand grows

The main building of a module will cover an area of about 1 500m² (53m x 29m), which means that about four modules would fit on a soccer field The height of the building will be 47,5m, half of which will be below ground level

THE PBMR IS COST EFFICIENT

South Africa has one of the lowest power costs in the world, based on its abundant low-cost coal. Current indications are that the PBMR's output cost would be in the same order as the cost of electricity produced by a new South African coal-fired plant situated at the pit-head The cost per unit of electricity produced would, however, be much lower than a coal-fired plant at the South African coast or the world average cost of US3,4c/kWh The costs of decommissioning, long-term storage of radioactive waste and insurance are included in these estimates Unlike Eskom's other low cost options such as coal and imported hydro, the PBMR costs are virtually independent of location.

The PBMR is relatively inexpensive to build compared with other energy generators The estimated cost is about US$1 million per MW of installed capacity, compared to US$900 000 per MW for a new coal-fired power station in South Africa This more than compensates for the cost of coal away from the the pithead

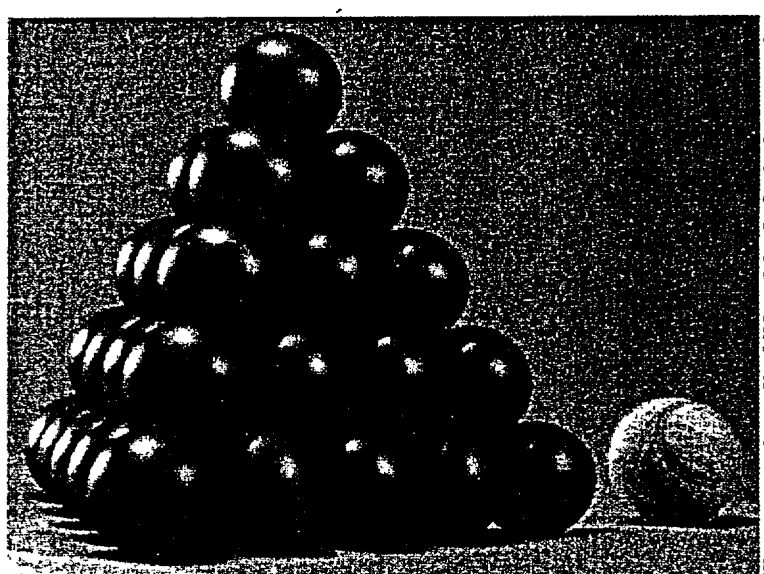
THE PBMR'S SAFETY FEATURES

The PBMR has a simple design basis, with passive safety features that require no human intervention and that cannot be by-passed or rendered ineffective in any way.

If a fault occurs during reactor operations, the system, at worst, will come to a standstill and merely dissipate heat on a decreasing curve without any core failure or release of radioactivity to the environment.

Its inherent safety is a result of the design, the materials used, the fuel and the natural physics involved, rather than the engineered active safety systems in a Pressure Water Reactor (PWR).

The helium, which is used to transfer



The pebbles, which are 60mm in diameter, are slightly smaller than a tennis ball.

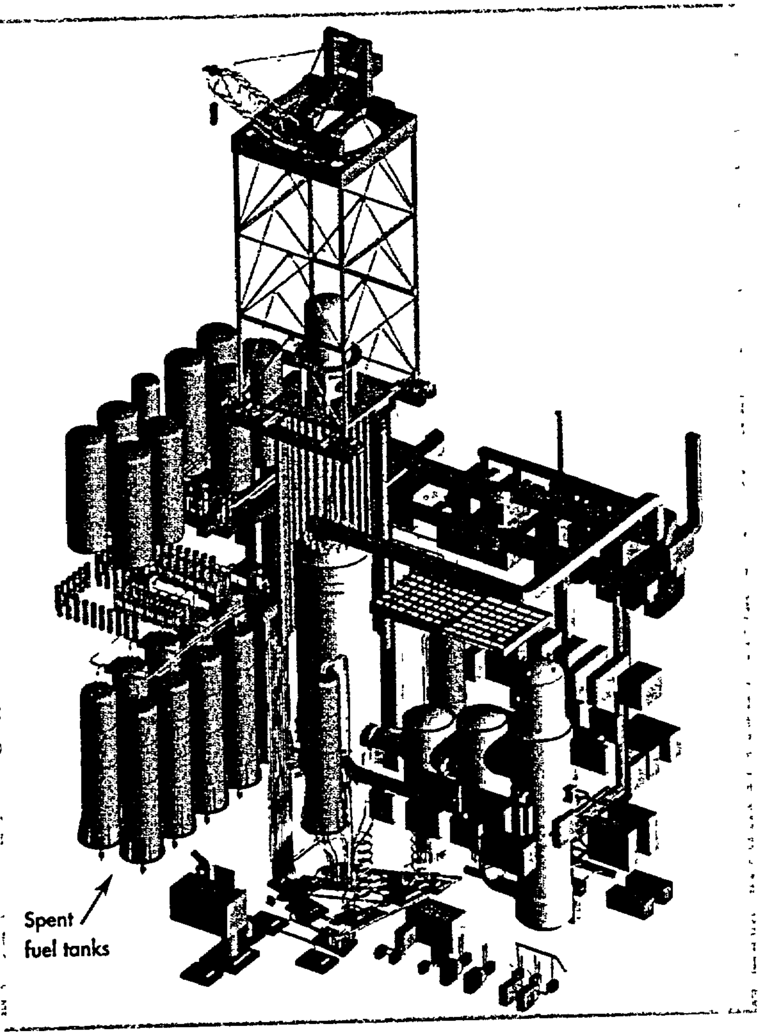
heat from the core to the power-generating gas turbines, is chemically and radiologically inert. It cannot combine with other chemicals, it is non-combustible and it cannot become radioactive when passed through the core.

The inherently safe design of a PBMR, which renders the need for safety grade backup systems and off-site emergency plans obsolete, is fundamental to the cost reduction achieved over other nuclear designs. One of the fundamental design differences between current generation reactors and High Temperature Gas-cooled Reactors (HTGRs) with coated particle fuel is the individual "containment" function of each fuel particle The inherent design of these fuel particles, coupled with the advanced design of the reactor, prevents a major or severe loss of containment.

NO GREENHOUSE GASES

The PBMR will provide an economic mitigation strategy for greenhouse gas reductions, since nuclear power generation produces no carbon dioxide emissions, smoke or any other gases. France's carbon dioxide emissions from electricity generation fell by 80 percent between 1980 and 1987 as its nuclear capacity increased, and Germany's nuclear power programme has saved the emission of over two billion tons of carbon dioxide from fossil fuels since it began in 1961

Emissions of sulfur dioxide in the US would have been three million tons higher and emissions of nitrogen oxides more than two million tons higher if utilities had built fossil plants instead of nuclear plants If, by some misfortune, all of America's 103 nuclear plants were shutdown and replaced by fossil plants, it would be necessary to remove 90 million automobiles from the nation's highways just to keep the level of emissions at the current levels



WASTE GENERATION AND DISPOSAL

A major advantage of radioactive waste is that it is so small in volume compared to the equivalent waste from, for example, a coal-fired power station One kilogram of natural uranium has the same energy output as 17 tons of coal with an ash content of up to 40 percent. A large coal-fired power station uses about six trainloads of coal a day, while a nuclear power station of equivalent capacity uses only one large truckload of fuel per year.

The PBMR will generate about 19 tons of spent fuel pebbles per annum, of which less than one ton is depleted uranium. The spent fuel is much easier to store than fuel rods from conventional nuclear reactors, as the silicon carbide coating on the fuel particles will keep the radioactive decay particles isolated for approximately a million years. This is longer than the activity of any of the radioactive products, including plutonium

The PBMR system has been designed to deal with nuclear waste efficiently and safely. There will be enough room for the spent fuel to be stored in dry storage tanks at the PBMR plant for the power station's expected 40-year life, during which time no spent fuel will have to be removed from the site.

After the plant has been shut down, the spent fuel can be safely stored on site for another 40 years before being sent to a final repository No decision has yet been made on the location of such a site.

ELECTRICITY DEMAND AND EXPORT POTENTIAL

If the promise of the PBMR pans out, it could dramatically boost the prospects of nuclear energy on a global scale, fulfilling at last the dream of a non-polluting power source that's safe, cheap and even popular

The recent flare-up of oil prices is a sobering reminder of the volatility in this market, the exhaustibility of fossil fuels and the urgent need for stable, reliable, non-polluting sources of electrical power that are indispensable to a modern industrial economy

As the world economy continues to expand due to the increased use of new technologies, so will demand for electricity International electricity demand is expected to increase by a massive 91 percent by 2020 As electricity demand increases, new plants will be needed both to accommodate the new demand and to replace plants built 40 to 50 years ago However, the public will not accept new plants that cause harm to the environment.

Throughout the world people are demanding a cleaner environment Global warming is a serious concern. Building more generating plants powered by solar and wind energy is one way to reduce greenhouse gases More wind and solar generating facilities will be constructed over the next two decades. But solar and wind power will not be sufficient to meet the growth in electricity demand over the next several decades, let alone replace outmoded plants. Other technologies such as fuel cells will make a contribution, but will not supersede the existing systems.

The most environmentally responsible way to meet demand will be through nuclear power. The PBMR therefore offers a unique opportunity for South Africa to develop an advanced industrial base in a globalised world economy. Significant export opportunities exist to First World countries as well as Third World and Developing World countries.

As the dominant economic power in Sub-Saharan Africa, South Africa is seen as instrumental to the economic upliftment of the region In fact, South Africa feels a moral obligation in this regard, as articulated by President Thabo Mbeki in his African Renaissance plan

The confidence in the PBMR's export potential is underscored by an independent assessment of the world market, which showed that up to 20 modules per year (which represent less than two percent of the world market's annual capacity requirements), could be exported once the technology has been fully demonstrated.

Similar to an aircraft manufacturer introducing a new type of plane, a project of this magnitude requires a "launch customer". To this end, Eskom has conditionally agreed to buy ten modules if the demonstration plant proves to meet financial expectations